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HIGH STRENGTH, HIGHLY GONDUCTIVE, HEAT RESISTING COPPER ALLOY
[Koryoku Kodendosei Tainesu Do Gokin]

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SPECIFICATION /139*

1. Title of the Invention

High Strength, Highly Conductive, Heat Resisting Copper Alloy

2. Scope of the Claims

A high strength, highly conductive, heat resisting copper alloy comprising one or more kinds of compounds, selected from any of the following: Ti 0.05 to 2.0 wt%, Sb, Ag, Te, Si, Cr, Co, Fe, P, Sn, Mg, Zr, Al, Mn, La, Ce, Y, Be, Ni in a total amount of 5.0 wt% or less, a remaining portion of Cu and irreversible impurities.

3. Detailed Description of the Invention

[Industrial Field of Application]

The present invention relates to a copper alloy having high strength, excellent conductivity and heat resistance, superior workability and plating ability (soldering ability), in particular, those which are suitable for uses in lead frames or connectors in semiconductor integrated circuits.

[Prior Art]

Generally, the following characteristics are demanded for lead frames and connectors in semiconductor integrated circuits.

(1) To have high strength and superior heat resistance.

(2) High heat radiation, namely high electro conductivity that is the same characteristic as heat conductivity

(3) Superior workability and plating adhesiveness (soldering property)

* Numbers in the margin indicate pagination in the foreign text.

Conventionally, 42 alloy (Fe-42 wt% Ni) is mainly used for lead frames and connectors in semiconductor integrated circuits. Although this alloy has excellent characteristics such as a tensile strength of 63 kg/mm2 and heat resistance of 670°C (temperature when the strength is reduced to 70% of that at the initial stage during a period of 30 minutes), the electro conductivity is inferior as indicated by the electro conductivity of 3% IACS.

Recently, high reliability, as well as an increase in the degree of integration and compactness, are required for semiconductor integrated circuits. Further, the modes of integrated circuits are changed from the prior DIP type IC to chip carrier and PGA types. For this reason, the lead frames in integrated circuits are formed in a thin film and in a compact shape and at the same time, characteristics that are superior to those of 42 alloys and are now in demand. Namely, in order to improve strength to prevent a reduction in the component parts by forming a thin film, and to improve heat radiation by increasing the degree of integration, there has been a demand for improving the electro conductivity, that is, the same characteristic as heat conductivity, further improving superior heat resistance, fixation on the frame of semiconductors, the plating property and plating adhesiveness to the lead frame surface as a gold wire bonding pre-treatment used in wiring of the foot portion of the lead frame.

[Problems to be Solved by the Invention] /140

The aforementioned 42 alloy has the drawbacks of reduced electro conductivity as indicated by 3% IACS and poor heat radiation. If a

copper alloy is used instead, the electro conductivity can be dramatically improved to 50 to 70% IACS. The same strength as the 42 alloy can be achieved by applying solubilization treatment to a section of the copper alloys.

However, there is a drawback that this solubilization treatment, including quenching and annealing, not only reduces its productivity, but also significantly increases the product cost.

[Means for Solving the Problems]

The inventors earnestly investigated under the aforementioned situation and developed a high strength, highly conductive, heat resisting copper alloy having the same strength and heat resistance as 42 alloy without a solubilization treatment and also showing excellent conductivity. The present invention is characterized in that a high strength, highly conductive, heat resisting copper alloy comprises one or more kinds of compounds, selected from any of the following: Ti 0.05 to 2.0 wt% (hereinafter wt% is simply abbreviated as %), Sb, Ag, Te, Si, Cr, Co, Fe, P, Sn, Mg, Zr, Al, Mn, La, Ce, Y, Be, Ni (hereinafter referred to as X) in a total amount of 5.0 % or less, a remaining portion of Cu and irreversible impurities.

[Operations]

When Ti is added to Cu, a Cu-Ti compound is formed and, if this is precipitated in Cu, strength and conductivity are known to be improved. The precipitation is accomplished by solubilization quenching at high temperature followed by an aging treatment. Ti forms a solid solution in Cu by solution heat treatment and a Cu-Ti

compound is then precipitated in Cu by subsequent quenching and aging treatments, which improve strength and conductivity. According to the present invention, Ti and a third element X are added to Cu. As a result, Ti is precipitated in Cu as Cu-Ti, Cu-Ti-X and Ti-X compounds by performing hot working, subsequent cold working and annealing at 500 to 650°C for one hour in the typical Cu alloy manufacturing process to present superior characteristics without carrying out high temperature solubilization quenching or aging treatments.

The strength of the alloy of the present invention is improved by precipitation of Cu-Ti, Cu-Ti-X and Ti-X compounds by performing hot working, subsequent cold working and annealing. The reinforcement effect is slightly weaker compared to the solubilization-quenching and aging of the Cu-Ti alloys, whereas sufficient strength is achieved by precipitating Cu-Ti-X and Ti-X compounds, along with Cu-Ti compounds. In terms of conductivity, even though Cu-Ti compounds are completely precipitated, conductivity is still 30% IACS with Ti at 2.0%. According to the present invention, a third element X is added so that Cu-Ti-X and Ti-X compounds are precipitated along with Cu-Ti compounds, resulting in significant improvement in conductivity.

Next, heat resistance is one of the important characteristics required for lead frames. In general, resistance at 400 to 500°C is adequate. This heat resistance has already been solved by adding Ti to Cu. However, if the amount of the addition of Ti is in the range of 0.7 to 2.0%, the heat resistance of the Cu-Ti alloy becomes 650°C or higher. This worsens the energy efficiency, such as the elevation of

the annealing temperature in the manufacturing process. Thus, according to the present invention, X is added such that the heat resistance is limited to a range of 400 to 500°C, but allowing annealing in a range of 500 to 650°C

Furthermore, plating adhesiveness (soldering property) is an essential condition for lead frames. Lead frames are generally coated with Ag, Sn, Sn-Pb (solder) by a plating or dipping method. If a lead frame is stored at 100 to 200°C after coating for a long time with only a very small mutual diffusion layer formed between the lead frame and the plating element, it is considered as having "good adhesiveness". If diffusion further advances, the element in the lead frame is diffused up to the plating surface, which worsens the bonding ability of the Au line connected to semiconductors and lead frames in the manufacturing process of integrated circuit parts. In particular, in the Cu-Ti alloy, the mutual diffusion layer becomes thick so that Ti, included in the form of a solid solution in Cu, is diffused to /141 form brittle compounds with Sn and Ag in the solder and plating material, which causes peeling of the plated layer. According to the present invention, in order to prevent this phenomenon, a third element X is added along with Ti to Cu so that the Ti is solubilized in Cu, forming Cu-Ti, Cu-Ti-X and Ti-X compounds to be precipitated. Thus, the effect of Ti causing brittleness of the diffused layer can be minimized.

The composition of the alloy of the present invention is limited, as mentioned above. If the Ti content is less than 0.05%, a sufficient

effect cannot be achieved. If it exceeds 2.0%, casting ability and workability decrease, which makes manufacturing difficult.

X-content is also limited to 5.0% or less. If X is added in an amount exceeding this limit, manufacturing becomes difficult due to the same reasons.

The present invention will be explained below with reference to examples.

[Examples]

Copper was dissolved in a graphite crucible and the molten surface was covered with charcoal powder. After thoroughly dissolving, Ti was added. Subsequently, X, as a third element, was added and alloys with the compositions shown in Table 1 were prepared. The alloy was cast in a cast block: width of 150 mm, thickness of 25 mm and length of 200 mm. After face milling of 2.5 mm per surface, a plate with a width of 150 mm and a thickness of 8 mm was formed by hot rolling. Subsequently, cold rolling and intermediate annealing (600°C, 1 hour) were repeated. A plate with a thickness of 0.25 mm was obtained by performing 40% processing by final cold rolling.

With respect to the samples prepared, conductivity, tensile strength, heat resistance, and plating adhesiveness were measured. The results are shown in Table 1.

A tensile test specimen specified by JIS-Z2201 was cut from the said rolled material. When the test specimen is heated under argon for 30 min., if the tensile strength becomes approximately 70% of the initial strength it is considered heat resistant.

Further, adhesiveness was tested as follows. A sample of 30 x 30 mm was cut from the material provided. After treating the surface, Ag plating was applied. It was heated in the air and swelling of the plated surface at the deeper side was observed. If no swelling is found after heating at 550°C for 5 minutes, the condition is recorded as "good", while if swelling is found, the condition is recorded as "poor".

Table 1 (1)

合金別 a) No	b) 合金組成 (%) Cu	Ti	X	c) 導電率 %IACS	d) 抗張さ Kg/mm²	e) メッキ密着性	f) 耐熱性 ℃
g) 本発明合金 1	h) 残	0.1	Sb 0.2	75	51	i) 良	390
〃 2	〃	0.1	Ag 1.5	67	52	〃	430
〃 3	〃	1.8	Te 0.5	49	62	〃	580
〃 4	〃	1.3	Si 1.6	50	63	〃	600
〃 5	〃	1.1	Cr 1.2	75	58	〃	530
〃 6	〃	1.1	Co 0.4	72	55	〃	550
〃 7	〃	1.1	Fe 0.8	70	55	〃	560
〃 8	〃	1.1	P 0.2	61	56	〃	520
〃 9	〃	1.1	Sn 1.5	55	53	〃	490
〃 10	〃	1.1	Mg 0.5	58	55	〃	430
〃 11	〃	1.1	Zr 0.2	75	56	〃	600
〃 12	〃	1.1	Al 2.5	43	58	〃	530
〃 13	〃	1.1	Mn 2.3	40	52	〃	460
〃 14	〃	1.1	Be 1.0	45	57	〃	560
〃 15	〃	1.1	Ni 0.8	65	62	〃	550
〃 16	〃	1.1	Ni 3.0 Cr 0.4	64	58	〃	570
〃 17	〃	1.1	Fe 0.6 Si 0.2	59	59	〃	580
〃 18	〃	1.1	Sn 2.2 Ni 1.8	51	72	〃	570
〃 19	〃	1.1	Ni 2.0 Si 1.2	54	65	〃	590
〃 20	〃	1.1	Sn 1.2 Cr 0.4 Mg 0.2	53	55	〃	550

Key:
a) Alloy No.; b) Alloy composition (%); c) Conductivity %IACS; d) Tensile strength Kg/m^2; e) Plating adhesiveness; f) Heat resistance °C; g) Alloy 1 of the present invention; h) Remaining; i) Good.

Table 1 (2)

a) Alloy No.		b) Alloy composition (%)			c) Conductivity %IACS	d) Tensile strength Kg/m²	e) Plating adhesiveness	f) Heat resistance °C
		Cu	Ti	X				
g)	21	i)	1.5	—	32	46	j)	650
〃	22	〃	0.01	Ni 0.8	80	35	k)	280
〃	23	〃	2.3	Ni 0.8	—	—	—	—
〃	24	〃	1.5	Ni 6.0	—	—	—	—
h)	25	Fe-42%Ni			3	63	k)	670

Key: a) Alloy No.; b) Alloy composition (%); c) Conductivity %IACS; d) Tensile strength Kg/m^2; e) Plating adhesiveness; f) Heat resistance °C; g) Alloy 21 of Comparative Example; h) Conventional Alloy 25; i) Remaining; j) Poor; k) Good

As clearly shown in Table 1, Alloys No. 1 through No. 20 of the present invention demonstrated adequate heat resistance as lead frames and connectors. When compared to the prior Alloy No. 25, the strength and plating adhesiveness were the same, but conductivity was far superior.

In contrast, in the case of Alloy No. 21, as a comparative example without adding the third element X, the strength and conductivity were poor. Alloy No. 22, containing less Ti content, demonstrated inferior strength and heat resistance. In Alloy No. 23, containing a high Ti content, and Alloy No. 24, containing a high content of X as a third element, the casting ability and workability were found to be poor so that they were unable to be processed to form a sheet material.

[Effects of the Invention]

According to the present invention, the alloys were produced easily at a low cost and demonstrated excellent conductivity, tensile

strength, plating adhesiveness and heat resistance. In particular, when these alloys are used as lead frames in integrated circuits, it was demonstrated to increase the degree of integration, thin the film and form a compact size. Therefore, the present invention has a remarkable industrial value.